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TITLE: Force feedback interface with selective disturbance filter
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INVENTOR-INFORMATION:

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CLAIMS:

What is claimed is:
1. A force feedback interface device implementing a selective disturbance filter for reporting filtered data to a host computer system, said host computer system implementing and displaying a graphical environment, the interface device comprising:
a user manipulatable object physically contacted by a user and movable in physical space in a degree of freedom with respect to a ground;
a sensor operative to detect said movement of said user manipulatable object in physical space in said degree of freedom with respect to said ground and output sensor signals representative of said movement;
an actuator coupled to said user manipulatable object and operative to apply an output force in said degree of freedom of said user manipulatable object; and
a microprocessor, separate from said host computer, coupled to said sensor and to said actuator, said microprocessor operative to receive host commands from said host computer and output force signals to said actuator to control said output force on said user manipulatable object, and operative to receive

said sensor signals from
said sensors and report locative data to said host computer derived from said sensor
signals and indicative of said movement of said user manipulatable object, said host
computer updating a graphical environment based on at least a portion of said
locative data, wherein said microprocessor implements a selective disturbance filter
for modifying said locative data reported to said host computer when said output
force causes said user manipulatable object to move and would cause an undesired
change in position of said user manipulatable object to be reported to said host
computer if said modification of said locative data were not performed.

2. A force feedback interface device as recited in claim 1 wherein said selective
disturbance filter is associated with at least one force sensation controlled by
said microprocessor, such that said selective disturbance filter modifies said
reported data only when said associated force sensation is output by said actuator.

3. A force feedback interface device as recited in claim 2 wherein a plurality of
different types of force sensations can be commanded by said microprocessor to be
output by said actuator, and wherein said at least one of said different types of
force sensations can be commanded by said host computer by providing a host command
to said microprocessor, wherein said selective disturbance filter is activated by
said host computer by providing a host command.

4. A force feedback interface device as recited in claim 3 wherein said modifying
of said locative data is performed if said output force sensation is associated with
said selective disturbance filter that has previously been commanded to be active by
said host computer.

5. A force feedback interface device as recited in claim 3 wherein at least one of
a plurality of available selective disturbance filters may be used to modify said
locative data.

6. A force feedback interface device as recited in claim 1 wherein said
modification of said locative data includes sampling said locative data over time
according to a sampling rate, and reporting only said sampled locative data to said
host computer.
7. A force feedback interface device as recited in claim 1 wherein said
modification of said locative data includes time-averaging said locative data and
reporting said averaged data to said host computer.
8. A force feedback interface device as recited in claim 1 wherein said
modification of said locative data includes sampling and holding a data value
derived from said sensor signals before said force sensation is output, wherein said
held data value is reported to said host computer during said force sensation.
9. A force feedback interface device as recited in claim 1 wherein said
modification of said locative data includes using a spatial filter to sample and
hold a data value derived from said sensor signals, said data value representing a
last position of said user manipulatable object before said user object is moved out
of a predetermined region in said graphical environment.
10. A force feedback interface device as recited in claim 1 wherein said different
types of force sensations include a vibration that causes a disturbance of a
vibrating cursor when said reported locative data is not modified.
11. A force feedback interface device as recited in claim 10 wherein said different
types of force sensations include a jolt that causes a disturbance of a cursor that
is suddenly moved in a direction corresponding to said jolt when said reported
locative data is not modified.
12. A method for selectively filtering visual disturbances associated with forces
occurring in a force feedback system, the method comprising:
enabling a reception of a command at a force feedback interface device from a host

computer to output a force sensation on a user manipulatable object of said force feedback interface device;
enabling a determination of whether said force sensation is associated with a disturbance filter process stored in a computer readable medium;
enabling a determination of whether said associated disturbance filter process is enabled;
enabling a filtering of input data according to said associated disturbance filter process to provide filtered input data, said filtering being performed if said associated disturbance filter process is enabled, said input data being received from sensors during said output of said force sensation and being representative of a position of said user manipulatable object in a degree of freedom, wherein said filtered input data is substantially free of a disturbance on said user manipulatable object caused by said output of said force sensation; and
enabling a report of said filtered input data to said host computer, said host computer using at least part of said filtered data to update a displayed graphical environment.

13. A method as recited in claim 12 further comprising enabling a reception of a command from said host computer to enable said associated disturbance filter process.

14. A method as recited in claim 12 wherein said filtered data is used by said host computer to position a cursor in a graphical environment.

15. A method as recited in claim 12 wherein said force sensation is one of a plurality of different available force sensations that may be output by said force feedback interface device, wherein at least two of said force sensations are associated with different disturbance filter processes.

16. A method for selectively decoupling an input channel from an output channel in a force feedback interface device by filtering input data, the method comprising:

outputting a force sensation in a degree of freedom of a user manipulatable physical object of said force feedback interface device, said force sensation being correlated with an event in a graphical environment implemented by a host computer coupled to said force feedback interface device;

determining whether said force sensation is associated with a disturbance filter process stored in memory of said force feedback device;

filtering input data according to said associated disturbance filter process to reduce a visual disturbance in said graphical environment caused by said output of said force sensation, said input data being received from sensors during said output of said force sensation and being representative of a position of said physical object in said degree of freedom; and

using said filtered input data to update said displayed graphical environment.

17. A method as recited in claim 16 further comprising determining whether said associated disturbance filter process is active, and performing said filtering only if said associated disturbance filter process is active.

18. A method as recited in claim 17 further comprising receiving a command from a host computer coupled to said force feedback interface device to activate said associated disturbance filter process.

19. A method as recited in claim 18 wherein said outputting of said force sensation is commanded by said host computer using a host command.

20. A method as recited in claim 16 wherein a plurality of disturbance filter processes are stored in said memory, and wherein said force sensation is one of a plurality of different available force sensations that may be output by said force feedback interface device, wherein at least two of said force sensations are associated with different ones of said disturbance filter processes.

21. A method for selectively decoupling an input channel from an output channel in a force feedback interface device by filtering input data, the method comprising:

enabling an output of a force sensation in a degree of freedom of a user
manipulatable physical object of said force feedback interface device, said force
sensation being correlated with an event in a graphical environment implemented by a
host computer coupled to said force feedback interface device;
enabling a determination of whether said force sensation is associated with a
disturbance filter process stored in memory of said force feedback device;
enabling a filtering of input data according to said associated disturbance filter
process to reduce a visual disturbance in said graphical environment caused by said
output of said force sensation, said input data being received from sensors during
said output of said force sensation and being representative of a position of said
physical object in said degree of freedom; and
enabling a update of said displayed graphical environment using said filtered input
data.

22. A method as recited in claim 21 wherein a plurality of disturbance filter
processes are stored in said memory, and wherein said force sensation is one of a
plurality of different available force sensations that may be output by said force
feedback interface device, wherein at least two of said force sensations are
associated with different ones of said disturbance filter processes.

23. A method for reducing disturbances in input data from a force feedback device,
the method comprising:
enabling an output of a force sensation from a force feedback device; and
enabling a filtering of said input data according to a disturbance filter process
associated with said force sensation to provide filtered input data, said input data
being received from at least one sensor of said force feedback device during said
output of said force sensation and being representative of movement of said user
manipulatable object in a degree of freedom, wherein said

filter input data is substantially free of a disturbance on said movement of said user manipulatable object caused by said output of said force sensation.

24. A method as recited in claim 23 wherein at least part of said filtered input data is used to update a displayed graphical environment.

25. A method as recited in claim 24 wherein a position of a graphical object in said graphical environment is updated using said filtered input data.

26. A method as recited in claim 23 further comprising enabling a report of said filtered input data to a host computer in communication with said force feedback device.

27. A method as recited in claim 24 wherein said enabling an output of a force sensation and a said enabling a filtering of said input data is performed by a processor local to said force feedback device and separate from a host computer in communication with said force feedback device.

28. A method as recited in claim 24 wherein said enabling an output of a force sensation and said enabling a filtering of input data is performed by a driver running on a host computer in communication with said force feedback device.

29. A method as recited in claim 23 wherein said disturbance filter process can be enabled or disabled, and wherein said filtering is performed if said associated disturbance filter process is enabled.

30. A method as recited in claim 23 wherein said force sensation is output by at least one actuator of said force feedback device, and wherein said output of said force sensation is correlated with an event in said graphical environment implemented by a host computer in communication with said force feedback device.

31. A method as recited in claim 23 wherein said disturbance filter process modifies said input data only when said associated force sensation is output by said force feedback device.

32. A method as recited in claim 23 wherein said

disturbance filter process
modifies said input data by sampling said input data over time according to a
sampling rate, and using only said sampled input data as said filtered input data.
33. A method as recited in claim 23 wherein said disturbance filter process
modifies said input data by time-averaging said input data and reporting said using
said time-averaged data as said filtered input data.
34. A method as recited in claim 23 wherein said disturbance filter process
modifies said input data by sampling and holding a data value derived from said
input data before said force sensation is output, wherein said held data value is
used as said filtered input data.
35. An apparatus implementing a selective disturbance filter for filtering data
used in displaying objects in a computer-implemented graphical environment, the
apparatus comprising:
means for causing an output of a force sensation from a force feedback device; and
means for filtering said input data according to a disturbance filter process
associated with said force sensation to provide filtered input data, said input data
being received from at least one sensor of said force feedback device during said
output of said force sensation and being representative of movement of a user
manipulatable object of said force feedback device in a degree of freedom, wherein
said filtered input data is substantially free of a disturbance on said movement of
said user manipulatable object caused by said output of said force sensation.
36. An apparatus as recited in claim 35 wherein said means for filtering includes a
processor local to said force feedback device and separate from a host computer.
37. An apparatus as recited in claim 35 wherein said means for filtering is
included in a driver running on a host computer in communication with said force
feedback device.
38. An apparatus as recited in claim 35 wherein said force

feedback device includes
a sensor operative to detect said movement of said user manipulatable object in
physical space in said degree of freedom and output sensor signals representative of
said movement.

39. An apparatus as recited in claim 35 wherein said disturbance filter process
modifies said input data by sampling said input data over time according to a
sampling rate, and using only said sampled input data as said filtered input data.

40. An apparatus as recited in claim 35 wherein said disturbance filter process
modifies said input data by time-averaging said input data and reporting said using
said time-averaged data as said filtered input data.

41. An apparatus as recited in claim 35 wherein at least part of said filtered
input data is used to update a displayed graphical environment.

42. An apparatus as recited in claim 41 wherein a position of a graphical object in
said graphical environment is updated using said filtered input data.

43. An apparatus as recited in claim 35 wherein said force sensation is correlated
with an event in said graphical environment implemented by a host computer coupled
to said force feedback device.

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CLAIMS:

What is claimed is:
1. A force feedback interface device implementing a selective disturbance filter for reporting filtered data to a host computer system, said host computer system implementing and displaying a graphical environment, the interface device comprising:
a user manipulatable object physically contacted by a user and movable in physical space in a degree of freedom with respect to a ground;
a sensor operative to detect said movement of said user manipulatable object in physical space in said degree of freedom with respect to said ground and output sensor signals representative of said movement;
an actuator coupled to said user manipulatable object and operative to apply an output force in said degree of freedom of said user manipulatable object; and
a microprocessor, separate from said host computer, coupled to said sensor and to said actuator, said microprocessor operative to receive host commands from said host computer and output force signals to said actuator for controlling said output force on said user manipulatable object, and operative to receive

said sensor signals from
said sensors and report locative data to said host computer derived from said sensor
signals and indicative of said movement of said user manipulatable object, said host
computer updating a position of a user-controlled graphical object based on at least
a portion of said locative data, wherein said microprocessor implements a selective
disturbance filter for modifying said locative data reported to said host computer
when said output force would cause a disturbance to said user-controlled graphical
object, wherein said modification of said locative data is performed when said
output force on said user manipulatable object affects said position of said user
manipulatable object such that said host computer would display said user-controlled
graphical object in an undesired location on a display screen coupled to said host
computer.

2. A force feedback interface device as recited in claim 1 wherein said selective
disturbance filter is associated with at least one force sensation controlled by
said microprocessor, such that said selective disturbance filter modifies said
reported data only when said associated force sensation is output by said actuator.

3. A force feedback interface device as recited in claim 2 wherein a plurality of
different types of force sensations can be commanded by said microprocessor to be
output by said actuator.

4. A force feedback interface device as recited in claim 3 wherein said at least
one of said different types of force sensations can be commanded by said host
computer by providing a host command to said microprocessor.

5. A force feedback interface device as recited in claim 4 wherein said selective
disturbance filter is activated by said host computer by providing a host command.

6. A force feedback interface device as recited in claim 4 wherein said modifying
of said locative data is performed if said output force

sensation is associated with
said selective disturbance filter that has previously been commanded to be active by
said host computer.
7. A force feedback interface device as recited in claim 3 wherein at least one of
a plurality of available selective disturbance filters may be used to modify said
locative data.
8. A force feedback interface device as recited in claim 7 wherein at least one of
said plurality of selective disturbance filters may be commanded to be active by
said host computer.
9. A force feedback interface device as recited in claim 1 wherein said
modification of said locative data includes sampling said locative data over time
according to a sampling rate, and reporting only said sampled locative data to said
host computer.
10. A force feedback interface device as recited in claim 1 wherein said
modification of said locative data includes time-averaging said locative data and
reporting said averaged data to said host computer.
11. A force feedback interface device as recited in claim 1 wherein said
modification of said locative data includes sampling and holding a data value
derived from said sensor signals before said force sensation is output, wherein said
held data value is reported to said host computer during said force sensation.
12. A force feedback interface device as recited in claim 1 wherein said
modification of said locative data includes using a spatial filter to sample and
hold a data value derived from said sensor signals, said data value representing a
last position of said user manipulatable object before said user object is moved out
of a predetermined region in said graphical environment.
13. A force feedback interface device as recited in claim 1 wherein said different
types of force sensations include a periodic force, an impulse force, and a snap
force.

14. A force feedback interface device as recited in claim 13 wherein said periodic force is a vibration that causes a disturbance of a vibrating cursor when said reported locative data is not modified.

15. A force feedback interface device as recited in claim 13 wherein said impulse force is a jolt that causes a disturbance of a cursor that is suddenly moved in a direction corresponding to said jolt when said reported locative data is not modified.

16. A force feedback interface device as recited in claim 13 wherein said snap force is an attraction force associated with a target that causes a visual disturbance of a cursor overshooting said target when said reported locative data is not modified.

17. A force feedback interface device as recited in claim 2 wherein user controlled graphical object is a cursor.

18. A force feedback interface device as recited in claim 17 wherein said graphical environment is a graphical user interface.

19. A force feedback interface device as recited in claim 2 wherein user controlled graphical object is a simulated entity in a simulated environment of a graphical video game.

20. A force feedback interface device as recited in claim 19 wherein said selective disturbance filter is applied to locative data derived from sensor signals input to said microprocessor during an outputting of forces simulating a recoil of a simulated gun controlled by said user in said graphical video game.

21. A method for selectively filtering visual disturbances associated with forces occurring in a force feedback system, the method comprising:

receiving a command at a force feedback interface device from a host computer to output a force sensation on a user manipulatable object of said force feedback interface device;

determining whether said force sensation is associated with

a disturbance filter
process stored in a computer readable medium;
determining whether said associated disturbance filter process is enabled;
filtering input data according to said associated disturbance filter process to
provide filtered input data, said filtering being performed if said associated
disturbance filter process is enabled, said input data being received from sensors
during said output of said force sensation and being representative of a position of
said user manipulatable object in a degree of freedom, wherein said filtering
reduces a disturbance on a position of a user controlled displayed graphical object,
said disturbance existing if said input data were reported to said host computer
without said filtering, said disturbance being caused by said output of said force
sensation on said user manipulatable object; and
reporting said filtered input data to said host computer, said host computer using
at least part of said filtered data to update a position of said user controlled
displayed graphical object in a displayed graphical environment.

22. A method as recited in claim 21 further comprising receiving a command from
said host computer to enable said associated disturbance filter process.

23. A method as recited in claim 21 wherein said filtering includes time-sampling
said input data according to a predetermined periodic interval and providing said
sampled data as said filtered data.

24. A method as recited in claim 21 wherein said filtering includes time-averaging
said input data according to a predetermined averaging window and providing said
averaged data as said filtered data.

25. A method as recited in claim 21 wherein said filtering includes sampling and
holding a value of said input data, said value being received before said force
sensation is output, and reporting said held value as said filtered data.

26. A method as recited in claim 21 wherein said filtering

includes storing and
holding a data value representing a last position of said user manipulatable object
before said user manipulatable object exited a predetermined region in said
graphical environment, and reporting said last position value as said filtered data.

27. A method as recited in claim 21 wherein said force sensation is one of a
plurality of different available force sensations that may be output by said force
feedback interface device, wherein at least two of said force sensations are
associated with different disturbance filter processes.

28. An apparatus for providing force feedback to a user in conjunction with the
display and updating of a graphical environment by a host computer system coupled to
the apparatus, the apparatus comprising:
a user manipulatable object physically contacted by a user and movable in physical
space in a degree of freedom with respect to a ground;
sensor means operative to detect said movement of said user manipulatable object in
physical space in said degree of freedom with respect to said ground and output
sensor signals representative of said movement;
actuator means coupled to said user manipulatable object and operative to output a
force in said degree of freedom of said user manipulatable object;
means for outputting force signals to said actuator means to control said output
force on said user manipulatable object;
means for receiving said sensor signals from said sensors and reporting locative
data to said host computer derived from said sensor signals and indicative of said
movement of said user manipulatable object, said host computer updating a position
of a user-controlled graphical object based on at least a portion of said locative
data; and
means for filtering said locative data and reporting said filtered locative data to
said host computer when said output force would affect said position of said user
manipulatable object such that said locative data causes a

visual disturbance to
said user-controlled graphical object.
29. A force feedback interface device as recited in claim 28 wherein said visual
disturbance occurs when said output force on said user manipulatable object moves
said user manipulatable object such that said host computer would display said
visual disturbance in a location of said user-controlled graphical object on a
display screen coupled to said host computer.
30. A force feedback interface device as recited in claim 29 wherein said means for
filtering is associated with at least one force sensation controlled by said
microprocessor, such that said means for filtering filters said locative data when
said associated force sensation is output by said actuator.
31. A force feedback interface device as recited in claim 30 wherein said
associated force sensation is a jolt coordinated with a simulated recoil of a
simulated gun controlled by said user in said graphical environment.
32. A force feedback interface device as recited in claim 30 wherein a plurality of
different types of force sensations can be commanded by said microprocessor to be
output by said actuator.
33. A force feedback interface device as recited in claim 32 wherein said at least
one of said different types of force sensations can be commanded by said host
computer by providing a host command to said microprocessor, and wherein said
selective disturbance filter can be enabled by said host computer by providing a
host command.
34. A force feedback interface device as recited in claim 33 wherein said filtering
of said locative data is performed if said output force sensation is associated with
said selective disturbance filter that has previously been commanded to be active by
said host computer.
35. A force feedback interface device as recited in claim 28 wherein said filtering
of said locative data includes at least one of time

sampling said locative data over
time according to a sampling rate, time-averaging said
locative data, sampling and
holding a data value derived from said sensor signals
before said force sensation is
output, and sample and hold a data value derived from said
sensor signals, said data
value representing a last position of said user
manipulatable object before said
user manipulatable object is moved out of a predetermined
region in said graphical
environment.

36. A force feedback interface device as recited in claim 32 wherein said different
types of force sensations include a periodic force, an
impulse force, and a snap
force.

37. A method for selectively decoupling an input channel from an output channel in
a force feedback interface device by filtering input data,
the method comprising:
outputting a force sensation in a degree of freedom of a
user manipulatable physical
object of said force feedback interface device, said force
sensation being
correlated with an event in a graphical environment
implemented by a host computer
coupled to said force feedback interface device, said event
involving a
user-controlled graphical object displayed in said
graphical environment;
determining whether said force sensation is associated with
at least one of a
plurality of disturbance filters stored in a computer
readable medium;
filtering input data according to said at least one
associated disturbance filter to
reduce a disturbance in displaying said graphical object,
said input data being
received from sensors during said output of said force
sensation and being
representative of a position of said physical object in
said degree of freedom,
wherein said output of said force sensation would cause
said disturbance in
displaying said graphical object if said input data were
unfiltered; and
using said filtered input data to update said user

controlled graphical object in
said displayed graphical environment.
38. A method as recited in claim 37 further comprising determining whether said
associated disturbance filter process is enabled, and
performing said filtering only
if said associated disturbance filter process is active.
39. A method as recited in claim 38 further comprising receiving a command from a
host computer coupled to said force feedback interface device to activate said
associated disturbance filter process.
40. A method as recited in claim 39 wherein said outputting of said force sensation
is commanded by said host computer using a host command.
41. A method as recited in claim 37 wherein said force sensation is one of a
plurality of different available force sensations that may be output by said force
feedback interface device, wherein at least two of said force sensations are
associated with different disturbance filter processes.
42. A computer readable medium including program instructions for performing steps
of:
receiving sensor data from sensors on a force feedback interface device, said sensor
data representing motion of a user manipulatable object in a degree of freedom;
filtering said sensor data if said sensor data has been influenced by a force
sensation output by actuators of said force feedback interface device and if said
force sensation has been previously specified to require said filtering;
reporting said filtered sensor data to a host computer, said host computer
implementing a graphical environment and updating a user-controlled graphical object
based on said filtered sensor data.
43. A computer readable medium as recited in claim 42 wherein said filtering is
provided according to a selective filter process, wherein a plurality of selective
filter processes are available, each of said selective filter processes being
operative to filter input data influence by at least one of a plurality of different

force sensations that can be output by said force feedback interface device.

44. A method for selectively filtering visual disturbances associated with forces occurring in a force feedback system, the method comprising:

receiving a command at a force feedback interface device from a host computer to output a force sensation on a user manipulatable object of said force feedback interface device;

determining whether said force sensation is associated with a disturbance filter process stored in a computer readable medium, wherein said force sensation is one of a plurality of different available force sensations that may be output by said force feedback interface device, wherein at least two of said force sensations are associated with different disturbance filter processes;

determining whether said associated disturbance filter process is enabled;

filtering input data according to said associated disturbance filter process if said associated disturbance filter process is enabled, said input data being received from sensors during said output of said force sensation and being representative of a position of said user manipulatable object in a degree of freedom; and

reporting said filtered input data to said host computer, said host computer using at least part of said filtered data to update a position of a user controlled graphical object in a displayed graphical environment.